

1101 Connecticut Ave. N.W., Suite 910, Washington, D.C. 20036

June 14, 2000

Ms. Magalie Roman Salas Office of the Secretary Federal Communications Commission 445 Twelfth Street, S.W. 12<sup>th</sup> Street Lobby, TW-A325 Washington, DC 20554

Re: Comments in ET Docket No. 00-47 Inquiry Regarding Software Defined Radios

Dear Ms. Salas:

Enclosed please find an original and four copies of Nokia's comments in response to the Commission's Notice of Inquiry in the above-captioned proceeding. Also enclosed is a duplicate copy to be date stamped and returned. If you should have any questions or need further information, please do not hesitate to contact me at (202) 887-5210.

Sincerely,

Cecily Cohen

Manager, Government and Industry Affairs

Nokia Inc.

No. of Copies rec'd Of 4
List A B C D E

# Before the FEDERAL COMMUNICATIONS COMMISSION Washington, D.C.

Before the FEDERAL COMMUNICATIONS COMMISSION Washington, D.C.			
In the Matter of	)		
Inquiry Regarding Software Defined Radios	) ET Docket No. (	00-47	

#### Comments of Nokia Inc.

Nokia Inc. ("Nokia") hereby comments on the Commission's *Notice of Inquiry* in the above-captioned proceeding concerning the technical and regulatory implications of software defined radios ("SDR").

Nokia is a global company with over 56,000 employees with key growth areas in wireless and wireline telecommunications. As a pioneer in mobile telephony, Nokia is the world's leading mobile phone supplier as well as a top supplier of mobile and fixed telecom networks and services. As a leading technology company, Nokia is involved in research and development activities in all areas of telecommunications. Nokia is an active member of numerous international scientific organizations exploring the development of advanced technologies, including the Software Defined Radio Forum. Nokia is pleased to provide its views on the issues raised by the Commission in the Notice of Inquiry.

#### I. **INTRODUCTION**

As discussed in the *Notice of Inquiry*, SDR has the future potential for creating fully programmable systems with sufficient artificial intelligence to configure themselves to dynamic radio environments and spectrum sharing scenarios. SDR is a technology that could potentially enable the implementation of different radio air interfaces, interoperability between systems, or spectrum sharing. The future vision of SDR-based end-user equipment is analogous to personal computers, where the end user can easily upgrade or reconfigure his or her computer by changing components or software. These technological advancements could have implications for how spectrum and equipment is used and regulated.

Nokia, as an active participant in SDR research, views SDR technology as part of an evolutionary step along a path upon which we have already embarked, rather than a revolutionary development that will change the wireless industry overnight. SDR technology is expected to first be deployed in base-stations and in the longer-term be implemented in terminals. Nokia views the development of SDR technology as a continuous process with the division between hardware and software constantly evolving. For this reason, Nokia believes it is important to not "freeze" the division between software and hardware prematurely.

Nokia has committed significant resources to support research and innovation in this area and is encouraged by the progress made in some applications. However, Nokia believes that this exciting future vision is a long-term goal, unlikely to be reached earlier than 2010. Many technological hurdles remain to be overcome. Moreover, unlike personal computers, where the end-user may not mind a larger or slightly slower machine, today's market demands that portable consumer radio equipment be optimized in terms of cost, size, power consumption, and radio channel processing time. We do not

<sup>&</sup>lt;sup>1</sup> Inquiry Regarding Software Defined Radios, ET Docket No. 00-47, FCC 00-103 (rel. Mar. 21, 2000) (hereafter cited as "Notice of Inquiry")

believe that the outstanding technological issues can be resolved or that customer demands can be met in the short- or medium-term.

#### II. STATE OF SDR TECHNOLOGY

Nokia has been and continues to be a pioneer in developing programmable radio technologies for use in multi-band and multimode products. Our products utilize as much "general purpose" hardware circuitry as possible, including RF circuits, switchable RF components, and digital signal processing (hereafter referred to as "DSP") circuitry. This generic hardware is software-configured to operate with different system standards. As equipment is destined for multiple markets with different combinations of standards, the benefit of utilizing more generic digital circuitry is increased economies of scale.

Nokia expects that, as DSP technologies evolve, terminals will increasingly be designed using general purpose DSP circuitry, while the need for analog hardware circuitry will be reduced. The mix of software-based digital processing and hardware-based analog processing depends on the system standard requirements for each product. It is a continuously changing process that will evolve to optimize usage time, cost and product size. While not an issue for SDR or the questions the FCC is raising here, Nokia wants to emphasize the importance of agreeing on open interfaces for applications that users can download in their terminals, regardless of the systems standard or the manufacturer of the wireless terminal.

However, despite these advances, Nokia believes that we are far from reaching the goal of developing completely generic SDR equipment, where all system-specific components have been eliminated. Equipment that can handle a dynamic radio

environment and wide spectrum range requires components that have yet to be developed.

Other technological issues need to be addressed before such a system can be developed. For example, while direct sampling by an antenna could be deployed, interfering signals still need to be pre-filtered. In order to ensure spectral efficiency and radio system performance, interference rejection requirements should not be relaxed. Additionally, the issue of power consumption by radio frequency converters will need to be resolved before the concept of generic SDR can be feasible as a consumer product.

#### III. INTEROPERABILITY

The future promise of SDR technology is that it will increase interoperability between different systems by creating equipment that operates over a wide range of frequency bands and modes. In theory, this would increase spectral efficiency and create economies of scale for equipment.

With respect to commercial wireless systems, Nokia views SDR as a technology for implementing systems, not a system or air interface standard. Interoperability between commercial wireless systems will depend more on the business case for the operators than the implementing technology. Nokia believes that the business case for SDR technology is not currently mature enough to support widespread use of SDR-based terminals in the near- or medium-term. Limited multi-band, multimode handsets are currently feasible with or without SDR technology, but with increased cost and complexity. The promise of SDR technology, when mature, is to allow utilization of

economies of scale to manufacture radio equipment that operates over a wide range of bands and modes at a price that is acceptable to operators.

More importantly, this additional cost and complexity may not be justified for the end-user, for whom frequency bands or system standards are of secondary interest. End-users typically switch phones or systems to find new and better services and features (e.g. a smaller, lighter phone, a new type of information service focusing on news or banking that requires new displays or input buttons for the handset, or future value-added applications such as location-based information). SDR technology cannot provide these additional functionalities and therefore may not be attractive to the end-user.

Public safety systems have substantially different technological and operational requirements than commercial wireless systems. These public safety systems require: (1) features and functions that support efficient intra-organizational communications for critical missions; (2) fast speed of connection; and (3) reliable and rugged equipment—particularly handsets—that can operate in demanding conditions.

While public safety system technologies were relatively simple in the past, these technologies have become more similar to cellular technologies. The demand for increased functionalities, wider service area coverage, and systems shared by multiple user organizations has resulted in public safety technology that is more complex than many commercial technologies.

In terms of market size, the number of public safety users is relatively stable with an annual growth rate of approximately two to three percent globally. The number of land mobile radio (LMR) users, including both LMR and Specialized Mobile Radio (SMR) users, currently grows at a rate of roughly four to five percent worldwide. In

contrast, the number of cellular subscribers grows at a rate almost 20 times higher than the growth rate for public safety systems users. The difference between these two subscriber growth rates is expected to increase quickly, with cellular subscribers growing at a rate of 40 times than of public safety users within two years.

Given the trends of more complex technology serving a limited and slow-growing market, it is increasingly important that unnecessary additional technological requirements be kept to a minimum so that R&D efforts can continue and equipment costs can be kept acceptably low. Within this framework, Nokia does not believe that SDR technology is a viable option for public safety systems in the foreseeable future. It is possible that future generations of SDR technology could provide a basis for public safety applications; however, Nokia believes that the next generation of SDR technology will not be available until 2010 or later.

#### IV. SPECTRUM EFFICIENCY AND SPECTRUM SHARING

In the future, there will be an increased need for multi-band, multimode equipment due to the co-existence of several generations of mobile communications systems and the continuation of national and regional differences in frequency plans despite global harmonization efforts.

Typically, user traffic on telecommunications networks varies as a function of time. At any particular point in time, some mobile networks will have unused spectrum and available capacity while other networks may be congested. Operators and users could benefit if traffic can be tuned in a flexible way to any frequency range where available capacity and the required services are available. Nokia expects that SDR

technology will evolve to provide greater flexibility in spectrum use by making unused capacity available and increasing overall traffic within a small range of frequency bands. However, it should be noted that this type of operation could require that the transmit-receive characteristics of the equipment be altered according to the service or network.

SDR technology will not be able to replace the need for additional spectrum for new and existing wireless systems. Spectral efficiency depends largely on system specific characteristics that are determined by system standards and specifications, not by enabling technologies such as SDR. The current trend is that new systems are becoming more spectrally efficient than previous systems. The development of equipment capable of increasing its efficient use of spectrum through software downloads is not foreseeable in the near future.

In the short- and medium-term, spectrum harmonization should continue to be the main tool for providing benefits to end-users, vendors, operators and regulators.

Harmonized frequencies and channeling plans remain the best way to create economies of scale for wireless equipment and services. SDR cannot be a substitute for good spectrum management. Without spectrum harmonization, increased cost and complexity for equipment and services will hinder the evolution of a mobile information society.

Sharing can be possible in terms of time, frequency bands, code, or geography. It is expected that SDR will improve the dynamic use of spectrum, through increased flexibility of spectrum use within a certain frequency range. However, SDR is not expected to address key system parameters such as transmit power, which is a technical system parameter not specific to SDR, that need to be considered for spectrum sharing.

SDR should not add regulatory complexity when used in the context of fixed frequency assignments. However, spectrum management would be more complex if spectrum assignments and channeling plans were dynamic. Leaving spectrum management to the "spectrum owner" may not ensure sufficiently efficient spectrum use without additional regulatory measures.

Spectrum use through dynamic spectrum assignments for different services would significantly increase system complexity. Adding the necessary intelligence to monitor spectrum in order to detect use by other parties and to initiate dynamic communication between terminals and networks would require new interfaces and interworking between different services and systems, as well as more complex protocols and control mechanisms within those systems. These developments would create new and significant challenges for standardization. Given the increased complexity, Nokia views these solutions as viable only in the longer term.

## V. EQUIPMENT APPROVAL PROCESS

As Nokia views SDR as an enabling technology in its current phase, we expect that SDR will require few changes in the equipment approval processes in the short-term. Most radiocommunications equipment today contains software that, if improperly modified, would render the equipment non-compliant with current rules and regulations. Currently, the combination of software and hardware in equipment is certified and any upgrades to the software require the manufacturer to seek additional approvals.

Nokia believes that this situation will not require changes in the near- or mediumterm. The balance between software and hardware in equipment is already shifting as software provides more functionalities. Nokia views this shifting balance as a constantly evolving process and believes that at this stage, the manufacturer should continue to seek approvals for the "mix" of software and hardware used in its equipment.

In the longer-term, as SDR technology evolves to the next generation, the introduction of radios that can truly use spectrum in an adaptive manner will require new approaches to standardization and equipment approval. Nokia looks forward to working with the FCC to develop these procedures.

### VI. CONCLUSION

Nokia views SDR technology as a promising evolutionary development that could potentially enable the implementation of different radio air interfaces, interoperability between systems, or spectrum sharing. However, Nokia urges the Commission not to view SDR as a panacea for meeting these difficult challenges. There are significant technical and product development issues that must be resolved before commercial SDR technology can be produced. Companies such as Nokia are working to develop SDR to

implement in products where it is feasible to do so. There is no need for the Commission to adopt regulations that may serve to freeze this development prematurely.

Respectfully Submitted,

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